

# Nosocomial Infections: Rates

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# Rates: Numerators

- Number of infections
- Number of patients infected
- Note:
  - **Infections caused by multiple organisms of similar origin at the same site = single infection**
  - **In a patient with a previously established nosocomial infection, a second nosocomial infection should be recorded in two situations:**
    1. the appearance of clinical infection at a new and different site
    2. the appearance in culture of new and different organisms if deterioration in patient's condition

# Rates: Denominators

- Number of patients admitted (or discharged)
- Number of hospital days
- Number of device days

# Hospital Wide Rates

- Hospital wide nosocomial infection rate /100 Admissions for a given period: month, quarter, year.

$$= \frac{\text{Number of nosocomial infections}}{\text{Number of patients admitted}} * 100$$

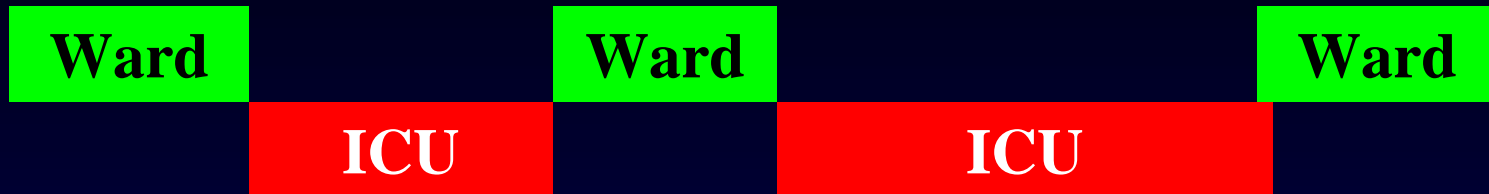
In this rate a patient with 2 infections is counted twice

- Hospital wide patient infected rate /100 Admissions for a given period: month, quarter, year

$$= \frac{\text{Number of patients infected}}{\text{Number of patients admitted}} * 100$$

In this rate a patient with 2 infections is counted only once

# Ward Specific Rates



- Rate of infection /1,000 HD  
=  $\frac{\text{Number of infections}}{\text{Number of hospital days}} * 1000$
- Rate of Patients infected /1,000 HD  
=  $\frac{\text{Number of patients infected}}{\text{Number of hospital days}} * 1,000$

# Device Specific Rates, Procedure Specific Rates

- Surgical Site Infection rate:  
=  $\frac{\text{Number of surgical site infections}}{\text{Number of patients operated on}} * 100$
- Ventilator Associated Pneumonia rate:  
=  $\frac{\text{Number of ventilator associated pneumonia}}{\text{Number of patients on ventilator-days}} * 1,000$
- Catheter Related Blood Stream Infection rate:  
=  $\frac{\text{Number of Catheter related BSI}}{\text{Number of patients on IV line-days}} * 100$

# How To Calculate A Device-Associated Infection Rate

- Step 1: Decide on the time period for analysis: month, quarter, 6 months, year
- Step 2: Select patient population for analysis, ie, type of ICU or a birthweight category
- Step 3: Select infections to be used in numerator
  - must be site-specific
  - must have occurred in selected patient population
  - date of onset must be during the selected time period

## How To Calculate A Device-Associated Infection Rate cont.

- Step 4: Determine number of device-days used as denominator

Device-days = total number of days of exposure to device (central line, ventilator, or urinary catheter) by all patients in selected population during selected time period

- Step 5: Calculate device-associated infection rate (per 1000 device-days) using the formula:

$$\text{Device-associated infection rate} = \frac{\text{Number of device-associated infections for specific site}}{\text{Number of device-days}} * 1000$$



# Utilization Rate

- The Device Utilization Rate (DUR) is the proportion of patient days for which a certain device is used
- DUR are specific to a certain device: catheter, IV line, ventilator
- DUR reflects the amount of devices used and is a reflection of the patient severity

$$= \frac{\text{Number of Device Days}}{\text{Number of Patient Days}} * 100$$

# Risk Adjustment

- **Systems assessing severity of illness**
  - APACHE (Acute Physiology & Chronic Health Evaluation)
  - Discharge diagnosis systems
  - Made for predicting mortality, not NI
- **Require individual evaluation of each member of denominator**

# APACHE II

THE APACHE II SEVERITY OF DISEASE CLASSIFICATION SYSTEM

PHYSIOLOGIC VARIABLE	HIGH ABNORMAL RANGE					LOW ABNORMAL RANGE			
	+4	+3	+2	+1	0	+1	+2	+3	+4
TEMPERATURE — rectal (°C)	≥ 41*	39*–40.9*		38.5*–38.9*	36*–38.4*	34*–35.9*	32*–33.9*	30*–31.9*	≤ 29.9*
MEAN ARTERIAL PRESSURE — mm Hg	≥ 160	130–159	110–129		70–109		50–69		≤ 49
HEART RATE (ventricular response)	≥ 180	140–179	110–139		70–109		55–69	40–54	≤ 39
RESPIRATORY RATE — (non-ventilated or ventilated)	≥ 50	35–49		25–34	12–24	10–11	6–9		≤ 5
OXYGENATION: A-aDO <sub>2</sub> or PaO <sub>2</sub> (mm Hg)									
a. FIO <sub>2</sub> ≥ 0.5 record A-aDO <sub>2</sub>	≥ 500	350–499	200–349		≤ 200				
b. FIO <sub>2</sub> < 0.5 record only PaO <sub>2</sub>					PO <sub>2</sub> > 70	PO <sub>2</sub> 61–70		PO <sub>2</sub> 55–60	PO <sub>2</sub> < 55
ARTERIAL pH	≥ 7.7	7.6–7.69		7.5–7.59	7.33–7.49		7.25–7.32	7.15–7.24	< 7.15
SERUM SODIUM (mMol/L)	≥ 180	160–179	155–159	150–154	130–149		120–129	111–119	≤ 110
SERUM POTASSIUM (mMol/L)	≥ 7	6–6.9		5.5–5.9	3.5–5.4	3–3.4	2.5–2.9		< 2.5
SERUM CREATININE (mg/100 ml) (Double point score for acute renal failure)	≥ 3.5	2–3.4	1.5–1.9		0.6–1.4		< 0.6		
HEMATOCRIT (%)	≥ 60		50–59.9	46–49.9	30–45.9		20–29.9		< 20
WHITE BLOOD COUNT (total/mm <sup>3</sup> ) (in 1,000s)	≥ 40		20–39.9	15–19.9	3–14.9		1–2.9		< 1
GLASGOW COMA SCORE (GCS): Score = 15 minus actual GCS									
<b>A</b> Total ACUTE PHYSIOLOGY SCORE (APS): Sum of the 12 individual variable points									
Serum HCO <sub>3</sub> (venous-mMol/L) [Not preferred, use if no ABGs]	≥ 32	41–51.9		32–40.9	22–31.9		18–21.9	15–17.9	≤ 15

## A AGE POINTS:

Assign points to age as follows:

AGE(yrs)	Points
≤ 44	0
45–54	2
55–64	3
65–74	5
≥ 75	6

## B CHRONIC HEALTH POINTS

If the patient has a history of severe organ system insufficiency or is immuno-compromised assign points as follows:

- for nonoperative or emergency postoperative patients — 5 points
- or
- for elective postoperative patients — 2 points

### DEFINITIONS

Organ insufficiency or immuno-compromised state must have been evident prior to this hospital admission and conform to the following criteria:

**LIVER:** Biopsy proven cirrhosis and documented portal hypertension; episodes of past upper GI bleeding attributed to portal hypertension; or prior episodes of hepatic failure/encephalopathy/coma.

**CARDIOVASCULAR:** New York Heart Association Class IV.

**RESPIRATORY:** Chronic restrictive, obstructive, or vascular disease resulting in severe exercise restriction, i.e., unable to climb stairs or perform household duties; or documented chronic hypoxia, hypercapnia, secondary polycythemia, severe pulmonary hypertension (>40mmHg), or respirator dependency.

**RENAL:** Receiving chronic dialysis.

**IMMUNO-COMPROMISED:** The patient has received therapy that suppresses resistance to infection, e.g., immuno-suppression, chemotherapy, radiation, long term or recent high dose steroids, or has a disease that is sufficiently advanced to suppress resistance to infection, e.g., leukemia, lymphoma, AIDS.

## APACHE II SCORE

Sum of **A** + **B** + **C** :

**A** APS points \_\_\_\_\_

**B** Age points \_\_\_\_\_

**C** Chronic Health points \_\_\_\_\_

Total APACHE II \_\_\_\_\_

# How to Calculate a Device Utilization Ratio

- Step 1: Decide on the time period for analysis: month, quarter, 6 months, year
- Step 2: Select patient population for analysis, ie, type of ICU or a birthweight category
- Step 3: Determine the number of device-days used as a numerator

Device-days = total number of days of exposure to the device (central line, ventilator, or urinary catheter) by all patients in the selected population during the selected time period

Note: Step 3 is the same as Step 4 in the device-day but here it is used as a numerator

## Device Utilization Ratio cont.

- Step 4: Determine the number of patient-days which is used as denominator of DU ratio

Patient-days = total number of days that patients are in the ICU during selected time period

- Step 5: Calculate the DU ratio with the following formula:

$$\text{DU ratio} = \frac{\text{Number of device-days}}{\text{Number of patient-days}}$$

Example DU =  $28/72 = 0.39$  or 39% of patient-days were also central line-days for the first week of the month

# Risk Adjustment

- For comparison: rates should be adjusted for risk factors
- Risk adjustment is labor intensive because data must be collected on the entire population at risk (denominator) rather than only the fraction with infections (numerator)
- Risk adjustment cannot correct for variability among data collectors in accuracy of finding and reporting events
- Current risk-adjustment methods improve but do not guarantee the validity of inter-hospital comparisons, especially comparisons involving facilities with diverse patient populations (e.g., community versus tertiary-care hospitals)

# Risk Adjustment By Stratification

- Stratification = calculation of rates separately in multiple categories for risk adjustment
- NNIS Example: device-associated infections are risk adjusted by
  - rates/1,000 device-days (SSI/1,000 central line-days)
  - stratifying by unit type
  - SSI risk adjustment of SSIs done by calculating of operation-specific rates stratified by a standardized risk index
  - do not incorporate all potential confounding variables
  - but acceptable level of risk adjustment
  - avoids data collection burden required to adjust for all variables
- Drawback:
  - small numbers of infections in any one category
  - unstable rates (small hospital with low surgical volume)

# Example: NNIS

- National Nosocomial Infections Surveillance (NNIS) System
- Established in 1970 with selected US hospitals reporting nosocomial infection surveillance data for aggregation into national database
- Identity of the nearly 300 participating hospitals confidential
- All NNIS data collected using standardized protocols, called "surveillance components":
  - Adult and pediatric intensive care unit (ICU)
  - High-risk nursery (HRN)
  - Surgical patient



## Severity: Surgical Patients, NNIS

- Record on every patient undergoing selected procedure generated with risk factors information for SSI
  - Wound class  
*(Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Am J Infect Control 1999;27:97-134.)*
  - Duration of operation
  - American Society of Anesthesiology (ASA) score  
*(Owens WD, Felts JA, Spitznagel EL Jr. ASA physical status classification: a study of consistency of ratings. Anesthesiology 1978;49:239-43)*
- Using a composite index for predicting SSI risk after operation calculate rates by the number of risk factors present  
*(Culver DH, Horan TC, Gaynes RP, Martone WJ, Jarvis WR, Emori TG, et al. Surgical wound infection rates by wound class, operative procedure, and patient risk index. Am J Med 1991;91(Suppl 3B):152S-7S.)*

# BSI Rates

## NNIS, Jan 2002-June 2004

Central line-associated BSI rate <sup>†</sup>			
Type of ICU	No. of units	Central line-days	Pooled mean
Coronary	60	116,546	3.5
Cardiothoracic	48	182,407	2.7
Medical	94	312,478	5.0
Medical-surgical			
Major teaching	100	430,979	4.0
All others	109	486,115	3.2
Neurosurgical	30	56,645	4.6
Pediatric	54	161,314	6.6
Surgical	99	358,578	4.6
Trauma	22	70,372	7.4
Burn	14	43,002	7.0
Respiratory	6	12,593	4.8

# BSI Rates

## NNIS, Jan 2002-June 2004

Percentile				
10%	25%	50% (median)	75%	90%
1.0	1.5	3.2	7.0	9.0
0.0	0.9	1.8	2.7	4.9
0.5	2.4	3.9	6.4	8.8
1.7	2.6	3.4	5.1	7.6
0.8	1.6	3.1	4.3	6.1
0.0	0.9	3.1	5.8	10.6
0.9	3.0	5.2	8.1	11.2
0.0	2.0	3.4	5.9	8.7
1.9	3.3	5.2	8.2	11.9
—	—	—	—	—
—	—	—	—	—

# UTI Rates

## NNIS, Jan 2002-June 2004

### Urinary catheter-associated UTI rate\*

Type of ICU	No. of units	Urinary catheter-days	Pooled mean
Coronary	60	170,759	4.5
Cardiothoracic	48	193,424	3.0
Medical	94	448,161	5.1
Medical-surgical			
Major teaching	99	593,100	3.9
All others	108	757,531	3.3
Neurosurgical	29	99,039	6.7
Pediatric	52	104,788	4.0
Surgical	99	486,575	4.4
Trauma	22	104,181	6.0
Burn	14	44,342	6.7
Respiratory	6	17,784	6.4

# VAP Rates

## NNIS, Jan 2002-June 2004

Ventilator-associated pneumonia rate<sup>‡</sup>

Type of ICU	No. of units	Ventilator-days	Pooled mean
Coronary	59	76,145	4.4
Cardiothoracic	47	98,358	7.2
Medical	92	268,518	4.9
Medical-surgical			
Major teaching	99	320,916	5.4
All others	109	351,705	5.1
Neurosurgical	29	45,073	11.2
Pediatric	52	133,995	2.9
Surgical	98	253,900	9.3
Trauma	22	63,137	15.2
Burn	14	23,117	12.0
Respiratory	6	18,838	4.9

# Central Line Utilization

## NNIS, Jan 2002-June 2004

Central line utilization <sup>†</sup>			
Type of ICU	No. of units	Patient-days	Pooled mean
Coronary	60	305,911	0.38
Cardiothoracic	48	230,487	0.79
Medical	95	596,588	0.52
Medical-surgical			
Major teaching	100	759,464	0.57
All others	109	979,550	0.50
Neurosurgical	30	116,931	0.48
Pediatric	54	349,258	0.46
Surgical	100	590,220	0.61
Trauma	22	115,099	0.61
Burn	14	76,877	0.56
Respiratory	6	26,567	0.47

# UTI Utilization Rates

## NNIS, Jan 2002-June 2004

### Urinary catheter utilization\*

Type of ICU	No. of units	Patient-days	Pooled mean
Coronary	60	305,911	0.56
Cardiothoracic	48	230,487	0.84
Medical	94	596,588	0.75
Medical-surgical			
Major teaching	99	759,464	0.78
All others	108	979,550	0.77
Neurosurgical	29	116,931	0.85
Pediatric	53	349,258	0.30
Surgical	99	590,220	0.82
Trauma	22	115,099	0.91
Burn	14	76,877	0.58
Respiratory	6	26,567	0.67

# VAP Utilization Rates

## NNIS, Jan 2002-June 2004

Ventilator utilization <sup>‡</sup>			
Type of ICU	No. of units	Patient-days	Pooled mean
Coronary	60	305,911	0.25
Cardiothoracic	48	230,487	0.43
Medical	94	596,588	0.46
Medical-surgical			
Major teaching	99	759,464	0.43
All others	109	979,550	0.37
Neurosurgical	29	116,931	0.39
Pediatric	52	349,258	0.39
Surgical	99	590,220	0.44
Trauma	22	115,099	0.56
Burn	14	76,877	0.31
Respiratory	6	26,567	0.71



# High Risk Nursery BSI Rates

## NNIS, Jan 2002-June 2004

Umbilical and central line-associated BSI rate*			
Birth-weight category	No. of HRNs	Central line-days	Pooled mean
≤1000 g	104	204,468	9.1
1001-1500 g	98	95,254	5.4
1501-2500 g	97	79,904	4.1
>2500 g	94	97,202	3.5

Percentile				
10%	25%	50% (median)	75%	90%
1.6	5.4	8.5	11.6	16.1
0.0	1.8	4.0	7.4	12.2
0.0	0.0	3.2	6.5	8.9
0.0	0.0	1.9	4.1	7.4

# High Risk Nursery VAP Rates

## NNIS, Jan 2002-June 2004

Ventilator-associated pneumonia rate<sup>†</sup>

Birth-weight category	No. of HRNs	Ventilator-days	Pooled mean
≤1000 g	102	204,117	3.5
1001-1500 g	91	50,204	2.4
1501-2500 g	86	39,957	1.9
>2500 g	90	55,038	1.4

# High Risk Nursery Central Line Utilization Rates NNIS, Jan 2002-June 2004

Umbilical and central line utilization ratio\*

Birth-weight category	No. of HRNs	Patient-days	Pooled mean
≤1000 g	105	489,195	0.42
1001-1500 g	104	319,316	0.30
1501-2500 g	103	388,630	0.21
>2500 g	103	335,430	0.29

# High Risk Nursery Ventilator Utilization Rates NNIS, Jan 2002-June 2004

Ventilator utilization ratio<sup>†</sup>

Birth-weight category	No. of HRNs	Patient-days	Pooled mean
≤1000 g	105	489,195	0.43
1001-1500 g	104	319,316	0.16
1501-2500 g	103	388,630	0.10
>2500 g	103	335,430	0.17

# SSI Rates

## By Operative Procedure & Risk Index

### January 1992 – June 2004

Operative procedure category		Duration cut point (h)	Risk index category	N	Rate	Risk index category	N	Rate	Risk index category	N	Rate	Risk index category	N	Rate
CARD	Cardiac	5	0	2147	0.70	1	49,135	1.50	2,3	15,215	2.21		—	—
CBGB	CABG-chest and donor site	5	0	2718	1.25	1	380,340	3.39	2	82,535	5.43	3	246	9.76
CBGC	CABG-chest only	4	0	160	0.00	1	15,248	2.19	2,3	6,499	3.72		—	—
OCVS	Other cardiovascular	2	0,1	11,233	0.60	2	3828	1.28	3	153	3.92		—	—
ORES	Other respiratory	2	0,1,2,3	1728	2.43		—	—		—	—		—	—
THOR	Thoracic	3	0	1423	0.42	1	5250	0.99	2,3	1,984	2.47		—	—
APPY	See Table 7													
BILI	Liver/pancreas	5	0	482	3.11	1,2,3	1736	7.37		—	—		—	—
XLAP	Laparotomy	2	0	6414	1.71	1	8082	3.08	2	4,542	4.71	3	987	7.19
NEPH	Nephrectomy	4	0,1,2,3	3747	1.04		—	—		—	—		—	—
OGU	Other genitourinary	2	0	13,831	0.36	1	7896	0.85	2,3	1,953	2.92		—	—
PRST	Prostatectomy	4	0	2732	0.81	1,2,3	2389	2.05		—	—		—	—
FUSN	Spinal fusion	4	0	51,057	1.04	1	30,619	2.64	2,3	8,122	6.35		—	—
FX	Open reduction of fracture	2	0	16,142	0.79	1	26,372	1.41	2	5,081	2.81	3	523	4.97
HPRO	Hip prosthesis	2	0	44,454	0.86	1	71,336	1.65	2,3	18,941	2.52		—	—
KPRO	Knee prosthesis	2	0	66,360	0.88	1	74,029	1.28	2,3	18,051	2.26		—	—
LAM	Laminectomy	2	0	73,846	0.88	1	55,517	1.35	2,3	18,106	2.46		—	—

# SSI Rates

## By Operative Procedure & Risk Index

### January 1992 – June 2004

Operative procedure category		Risk index category	No. hospitals	Pooled mean rate	Percentile				
					10%	25%	50% (median)	75%	90%
CARD	Cardiac	1	109	1.50	0	0.47	1.2	1.78	2.91
CARD	Cardiac	2,3	88	2.21	0	0	1.47	3.03	4.67
CBGB	CABG-chest and donor site	0	33	1.25	0	0	0.49	2.14	3.38
CBGB	CABG-chest and donor site	1	184	3.39	1.56	2.17	3.17	4.36	6.02
CBGB	CABG-chest and donor site	2	174	5.43	2.28	3.64	5.16	7.64	9.86
CBGC	CABG-chest only	1	107	2.19	0	0	1.51	3.43	4.36
CBGC	CABG-chest only	2,3	69	3.72	0	0.99	2.44	4.47	7.02
OCVS	Other cardiovascular	0,1	36	0.60	0	0	0	0.67	1.83
OCVS	Other cardiovascular	2	23	1.28	0	0	0	1.1	2.33
THOR	Thoracic	0	21	0.42	0	0	0	0	2.34
THOR	Thoracic	1	37	0.99	0	0	0	1.3	2.73
THOR	Thoracic	2,3	22	2.47	0	0	1.64	3.54	6.04
APPY	Appendectomy	M	22	0.67	0	0	0	0.74	1.38
APPY	Appendectomy	0	47	1.31	0	0	1.13	2.05	3.24
APPY	Appendectomy	1	58	2.55	0	1.28	2.22	3.29	5.78
APPY	Appendectomy	2,3	39	4.85	0	1.63	3.97	5.97	10.15
CHOL	Cholecystectomy	M	88	0.45	0	0	0	0.53	1.17
CHOL	Cholecystectomy	0	92	0.68	0	0	0.4	1.12	2.38
CHOL	Cholecystectomy	1	76	1.78	0	0	1.32	3.11	5.12
CHOL	Cholecystectomy	2	46	3.27	0	0.56	3.23	4.65	6.6
COLO	Colon	M0	99	3.98	0	1.93	3.22	5	6.42
COLO	Colon	1	107	5.66	1.91	3.36	5.1	6.97	8.96
COLO	Colon	2	84	8.54	3.92	5.48	9.09	11.62	17.16
COLO	Colon	3	28	11.25	2.11	6.67	13.33	16.22	21.67

# SSI Rates: Coronary Artery Bypass Graft (CBGB) Operation by Risk Index Category & Specific Site, NNIS, January 1992 - June 2004

Risk index category	0		1		2		3	
Infection site	No. SSIs	Rate	No. SSIs	Rate	No. SSIs	Rate	No. SSIs	Rate
<b>Leg (Donor Site)</b>	<b>20</b>	<b>0.74</b>	<b>5436</b>	<b>1.43</b>	<b>2024</b>	<b>2.45</b>	<b>5</b>	<b>2.03</b>
Superficial incisional	15	0.55	4203	1.10	1577	1.91	5	2.03
Deep incisional	5	0.18	1233	0.32	447	0.54	0	0.00
<b>Chest</b>	<b>14</b>	<b>0.51</b>	<b>7440</b>	<b>1.96</b>	<b>2459</b>	<b>2.98</b>	<b>19</b>	<b>7.72</b>
Superficial incisional	7	0.26	2796	0.74	933	1.13	5	2.03
Deep incisional	4	0.15	2091	0.55	627	0.76	9	3.66
Organ/space	3	0.11	2553	0.67	899	1.09	5	2.03
<b>Total</b>	<b>34</b>	<b>1.25</b>	<b>12,876</b>	<b>3.39</b>	<b>4483</b>	<b>5.43</b>	<b>24</b>	<b>9.76</b>

Denominators for the risk categories are as follows: Category 0 = 2718; Category 1 = 380,340; Category 2 = 82,535; Category 3 = 246.

\*Per 100 operations.